STS-106/2A.2b
Flight Readiness Review

August 29, 2000

Scott Schoenherr

Johnson Space Center

EVA Project Office

EVA Mission Overview

- **EVA Capability**
  - 1 scheduled EVA for ISS hardware transfer and assembly
    - SM -X Docking Target Deployment
    - SM-FGB Power Cables (4 cables)
    - Magnetometer Pole Installation
    - SM-FGB TV-C&DH Cables (4 cables)
    - Orlan Tranzit Cable (1 cable)
  - Get ahead tasks:
    - No get ahead tasks being carried
  - 1 unscheduled EVA capability for mission success
  - 2 unscheduled EVA capability for Orbiter, RMS, and ODS contingencies

Scott Schoenherr
281-483-9892

EVA Training Status

- **Mockups and Training**
  - Crew has been trained in all tasks in the NBL and Russian Hydrolab
    - 1 additional run is required for prime crew on 9/2/00
  - Total Water hours (NBL + Hydrolab) = 203.5
  - Training ratios:
    - Lu (18.8:1)
    - Malenchenko (16.3:1)
    - Burbank (4.6:1)

Scott Schoenherr
281-483-9892

Fit Check and Sharp Edge Status

- **Tool to Tool**
  - Fit checks 100% complete (261 of 261)
    - Payload Bay - 20 of 20 completed
    - TSA - 65 of 65 completed
    - Middeck - 176 of 176 completed
- **Tool to Interface**
  - 55% completed (18 of 33)
  - Remaining 15 fit checks are Russian items that will not be completed
- **Sharp Edge Inspection**
  - Completed on the ICC exterior, all SHOSS Box stowed hardware and SHOSS Box exterior
  - Complete on all SpaceHab Stowed Hardware and Orbiter Payload Bay

Scott Schoenherr
281-483-9892

US EVA Hardware Summary

- **Revision 5 of the EVA Support Equipment List (ESEL) is approved**
  - No Open FIARs on GFE Hardware
  - No Open Certifications

- **EVA Hardware Requirements:**
  - Port Heavy Weight Tool Stowage Assembly
  - Sill mounted Portable Foot Restraint (Bay 2, STBD TSA location)
  - Forward Bulkhead Portable Foot Restraint
  - SAFER Logistics
    - 3 SAFER Units Manifested (2 in the middeck, 1 in SpaceHab)
    - New switch guard design will not be flown on STS-106

Scott Schoenherr
281-483-9892

Russian Hardware Summary

- **The following items are manifested on 2A.2b:**

– Tool Kit #10 (Contingency Tools)	SpaceHab
– Cartridge Belt with Wire Ties	Middeck
• Nippers/Dino Cutters	Middeck
• Russian Adapter (3)	Middeck
• Ratchet Wrench (2)	Middeck
• Extensions (2, long and short)	Middeck
– Power Cables and Reel	SHOSS Box
– TV-C&DH Cables and Reel	SHOSS Box
– Orlan Tranzit Cable and Carrier	SHOSS Box
– Magnetometer PFR and Pole	SHOSS Box
– Magnetometer Cover (down only)	SHOSS Box
– Cable Clamps (9)	SHOSS Box
– Russian Tether, Adjustable Tether and Bungees (2)	SHOSS Box

Scott Schoenherr
281-483-9892

Internal Transfer Summary

- **Russian Hardware Transferred:**
  - Cartridge Belt with Wire Ties
    - Nippers/Dino Cutters
    - Russian Adapters (3)
- **US Hardware Transferred:**
  - EVA/CHECs Hardware
  - Crew Hook Look Assemblies (4)
  - Orlan Tether Adapters (2)
  - Safety Tethers (2)
- **US Hardware planned for swap out or returned IF TIME AVAILABLE:**
  - Adjustable Equipment Tethers (2, from -301 to -309)
  - RET (Eq-Eq/PIP) (2, from -353 to -383)
  - RET (Lg.-Eq) (2, from -355 to -385)
  - Tool Carrier Assembly (1 down only, 1 left on orbit)
  - Waist Tethers (2 down only)

Scott Schoenherr
281-483-9892

EMU Logistics and Stowage

- **EMU Manifesting**
  - 3 EMU's
  - Additional waist brief, leg assemblies, and sizing rings for spares give 1 fault tolerance
  - 5 pair of gloves:
    - Lu (4000 series prime/backup)
    - Malenchenko (Phase VI Prime/4000 series backup)
    - Burbank (Phase VI Prime/no backup)
- **EMU Hardware Transfers for ISS-1 Crew:**
  - Fresnel Lens (3)
  - MAG III (2)
  - Comfort Gloves (3 pair)
  - Moleskin Tape
- **Revision 1 of the EVA Support Equipment List (ESEL) is approved**
  - No Open FIARs on GFE Hardware and No Open Certifications

Scott Schoenherr
281-483-9892

QPID #1066 - STS-101 Fit Check Process

- During STS-101 EVA, handrail #8 installation could not be performed due to interference with APAS cable bracket on Node 1
- Handrail task added to mission post FOR as get-ahead task
- Node handrail fit check performed at KSC 10/2/98 identified 2 locations that failed the fit check due to APAS cable routing
  - No paper written because no planned use at the time
- Fit Check results documented in Boeing test report
  - Not fully documented in EVA fit check matrix
- QPID #1066 formally opened to investigate fit check process
- Corrective Actions (completed):
  - Performed review of published EVA procedures thru 5A and compare to EVA fit check matrix
  - Updated standard fit check matrix format to allow for documentation of test reports
  - Updated matrix to include all EVA interfaces per element, not just planned tasks
  - MOD documented formal requirements to compare all published procedures against fit check matrix

Scott Schoenherr
281-483-9892

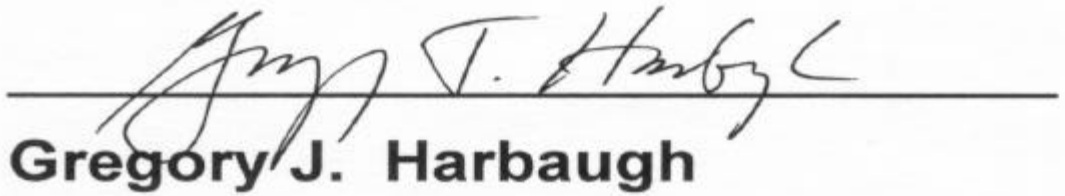
Open Work

No.	Title	Plan to Close	Resp. Org	ECD
XA-01	Finish Crew Training	Complete the final ETA runs, NBL runs and evaluations	DX32	9/2/00

Scott Schoenherr
281-483-9892

Readiness Statement

- All open work expected to be closed by L-2.
- The EVA Project Office is ready for launch pending completion of the defined open work.

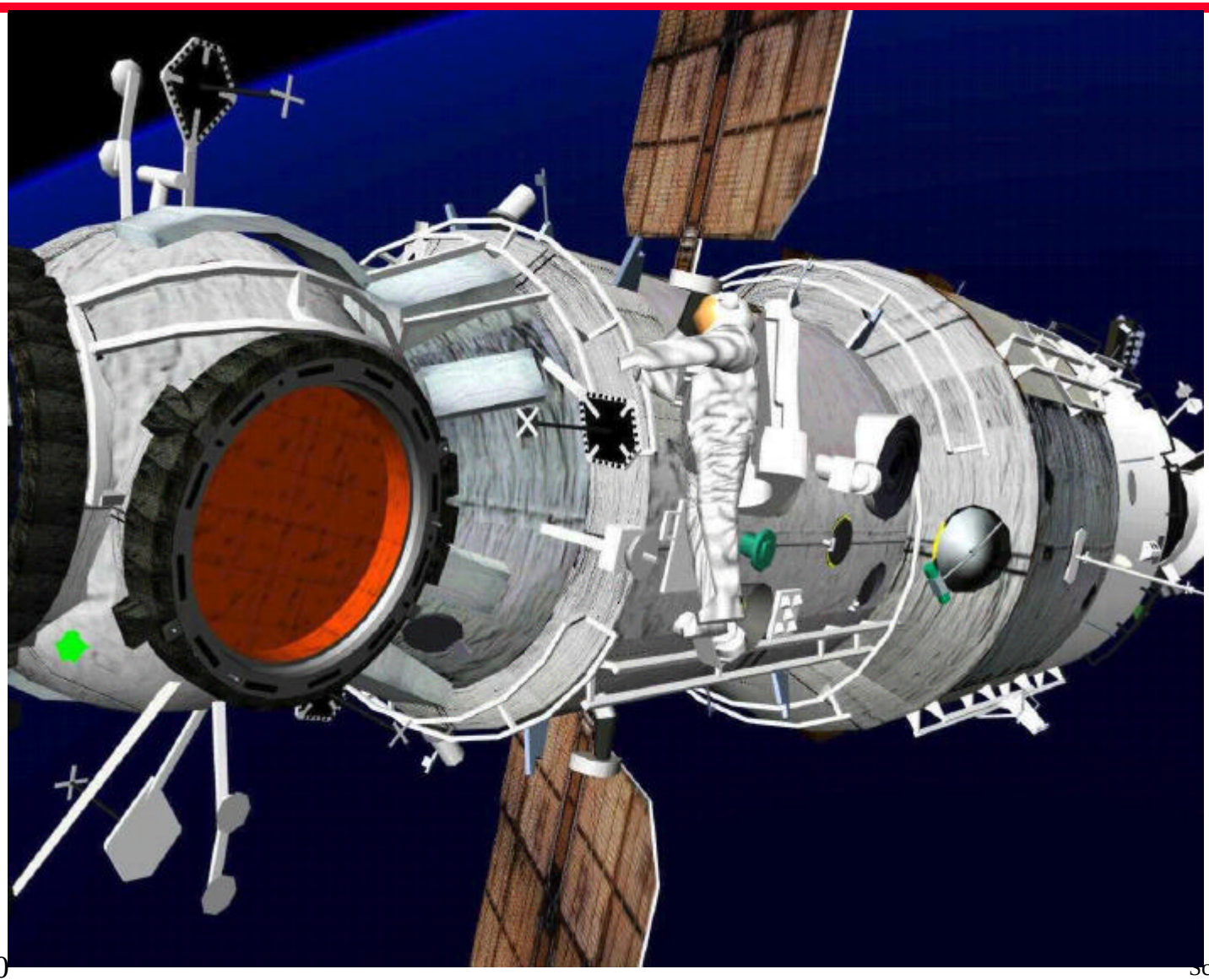


Gregory J. Harbaugh

Manager, EVA Project Office

Scott Schoenherr
281-483-9892

SM -X Docking Target Photos



Scott Schoenherr
281-483-9892

Russian Fit Checks

	Hardware Fit Check	Implications
1.	SM-FGB Power Cables	• Routing of cables not verified. Risk mitigated by adding extra length to the cables. • Connectors have not been verified. Failure to connect the cables will result in the inability to provide power to the Russian segment once P6 is installed on 4A.
2.	SM-FGB TV-C&DH Cables	• Routing of cables not verified. Risk mitigated by adding extra length to the cables. • Connectors have not been verified. Failure to connect the cables will result in the inability to provide internal TV to the SM during FGB nadir port dockings. Failure for C&DH cable connections are unclear, but we believe you will not have the ability to command the SM Solar Arrays from the FGB.
3.	Orlan Tranzit Cable	• Routing of cables not verified. Risk mitigated by adding extra length to the cables. • Connector has not been verified. Failure to connect the cable will result in the inability to provide hard-line communications from the Joint Airlock to the SM
4.	Magnetometer Cover Bolts (8)	• Eight non-captive bolts on the cover have not been fit checked to the US 12mm socket. • Potential that the cap would not be able to be removed and the Magnetometer task not completed which would slightly increase the ISS propellant consumption. • Risk is low based on other 12mm socket fit checks (cable clamps) and a Russian 12mm socket wrench will be available.
5.	Magnetometer Cover to BRT	• Interface was completed. Potential to be a nuisance for 2A.2b crew as they return item to the SHOSS Box.
6.	ONA launch restraint release tool	• Minimal/No risk since ONA has deployed
7.	ONA manual rotation wrench tool	• Minimal/No risk since ONA has deployed
8.	ONA electronics manual switching tool	• SM Vehicle issue, risk accepted at SM SORR
9.	ONA electronics backup box	• Unknown. Backup box has not been viewed. Potential that the ONA antenna (KU) will not function.
10.	SM Solar Array manual rotation	• Minimal to no risk. Solar arrays have deployed.
11.	SM Solar Array launch restraint release	• No risk. Solar arrays have deployed.
12.	SM TV Target launch restraint release	• Target pyro has fired, but not confirmed to be in the deployed position. 2A.2b looking at a plan for completing the deployment and will present to EVA CCB on 7/28.
13.	KURS launch restraint release	• No risk. KURs antennas have deployed.
14.	Regul antenna launch restraint release	• No risk. Solar arrays have deployed.
15.	Window cover manual open/close release	• Minimal to no risk. Implications would be lack of view port.

Scott Schoenherr
281-483-9892

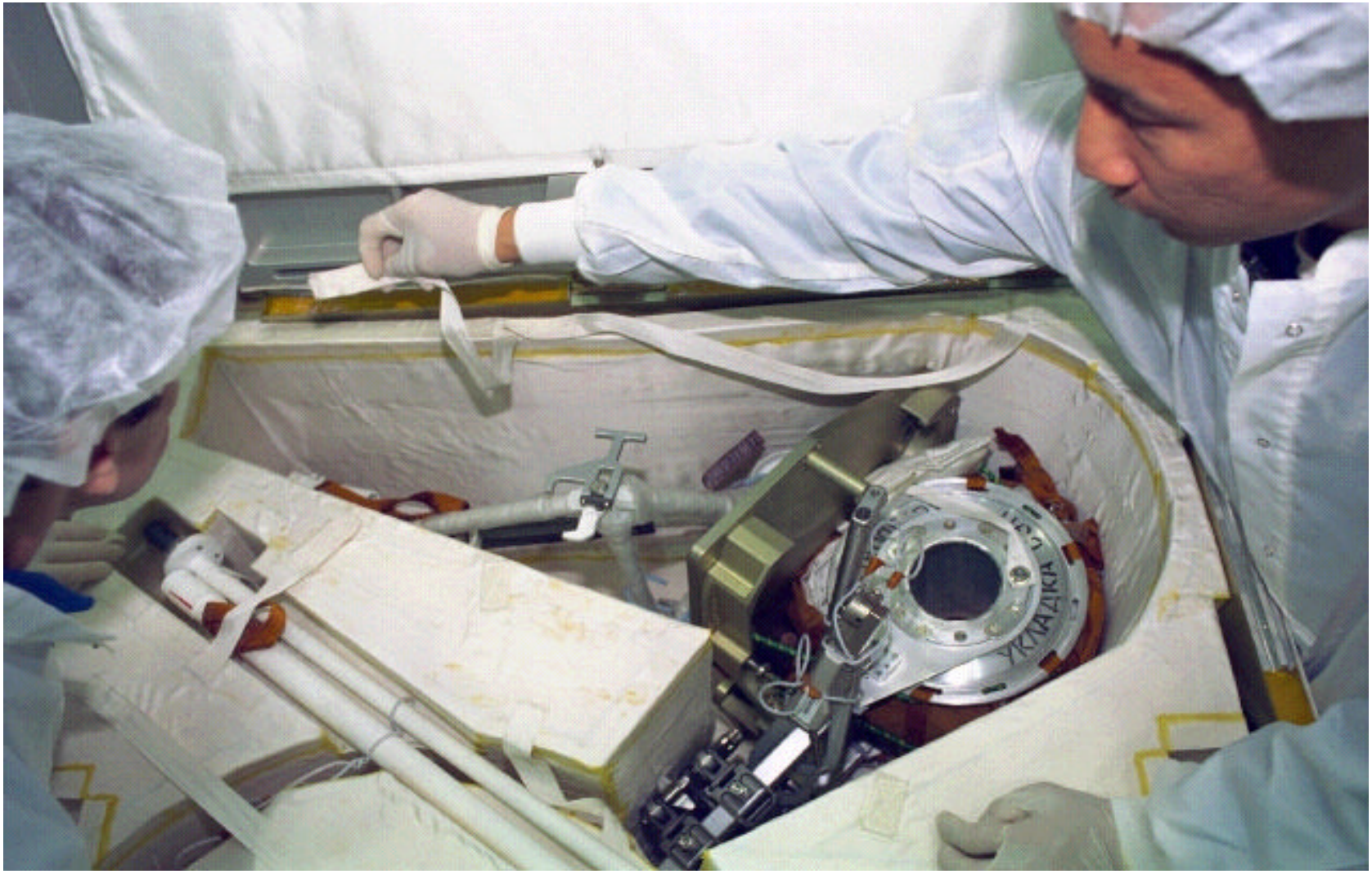
Tool Kit #10

Scott Schoenherr
281-483-9892

Russian Equipment

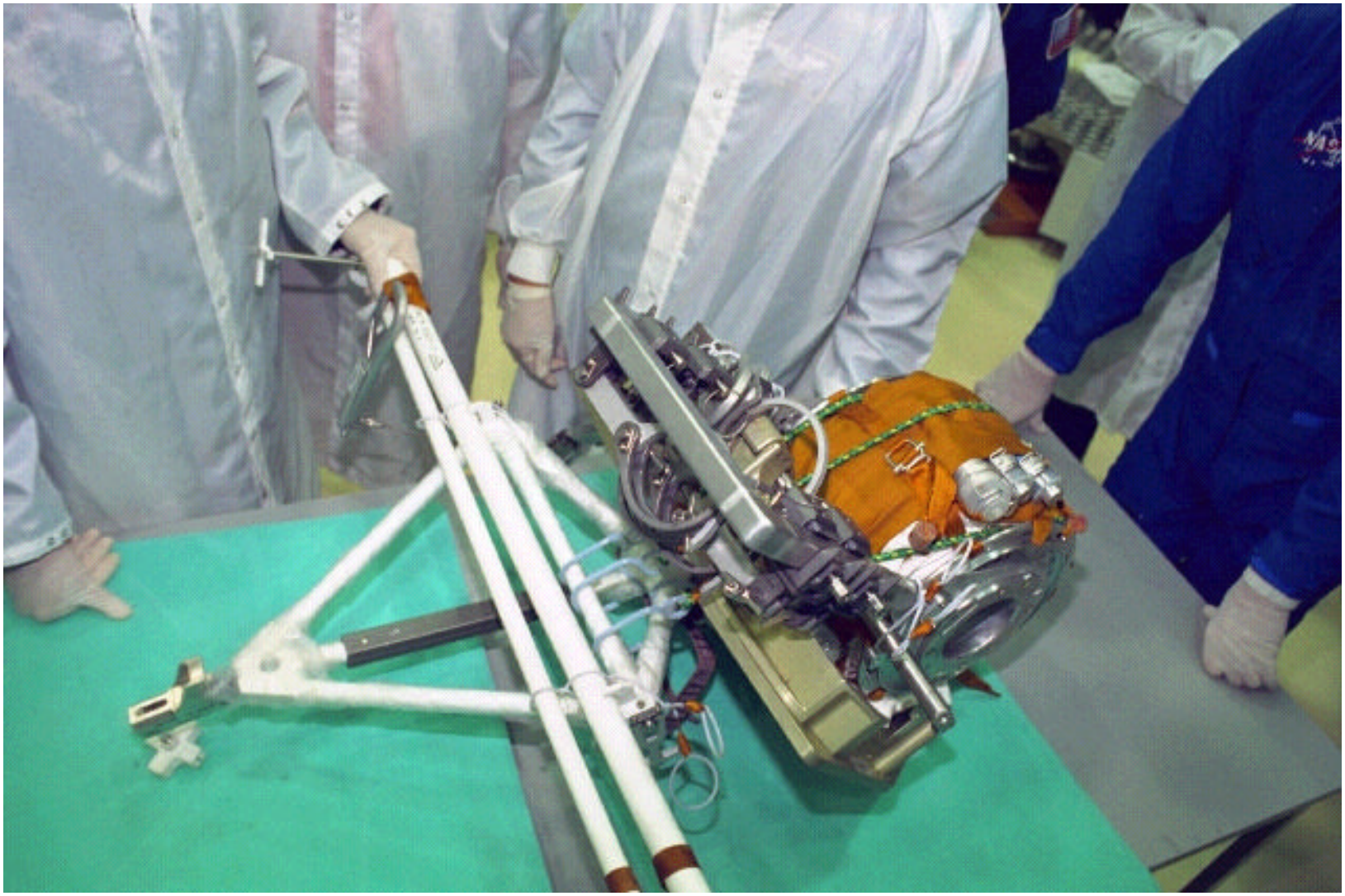
Scott Schoenherr
281-483-9892

External Hardware Summary



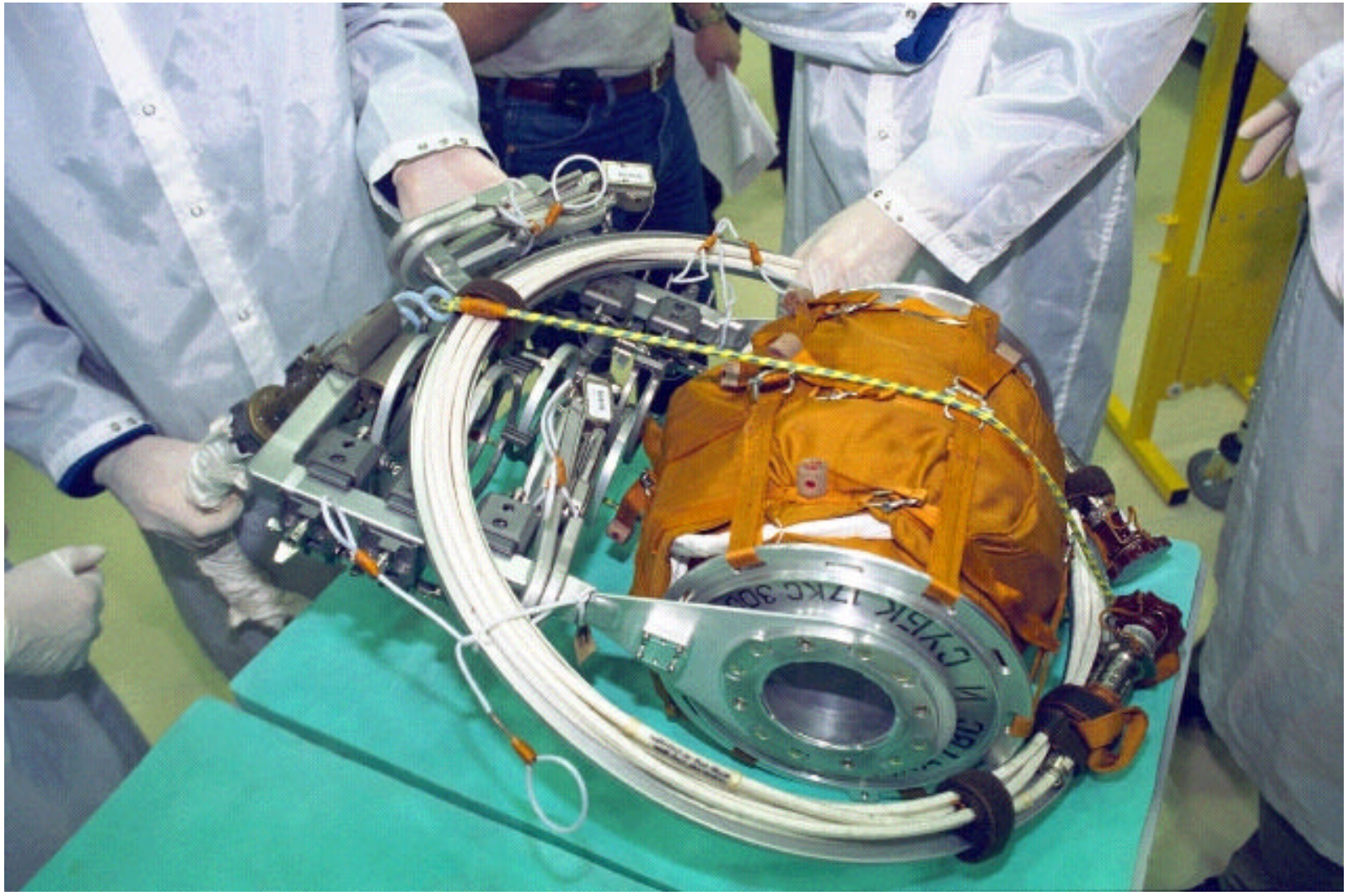
Scott Schoenherr
281-483-9892

External Hardware Summary



Scott Schoenherr
281-483-9892

External Hardware Summary



Scott Schoenherr
281-483-9892

STS-106 Flight Readiness Review

EMU Oxygen Contamination

EVA Project Office
August 29, 2000

EMU Oxygen Contamination

- **Agenda**
  - Background
  - Investigation
  - Root Cause
  - Corrective Action/Flight Readiness Rationale
  - Summary

EMU Oxygen Contamination

- **Background**
  - During investigation at the vendor (Carlton Technologies) for an internal leakage of Secondary Oxygen Pack (SOP) S/N 119 regulator, liquid droplets of contamination were noted
  - The contamination was determined to be a mix of fluorocarbons, hydrocarbons, and silicone oils. Subsequent inspection of other SOP regulators revealed contamination in all SOP regulators (range of contaminants was 3.3 to 233.3 mg/ft^2)

EMU Oxygen Contamination

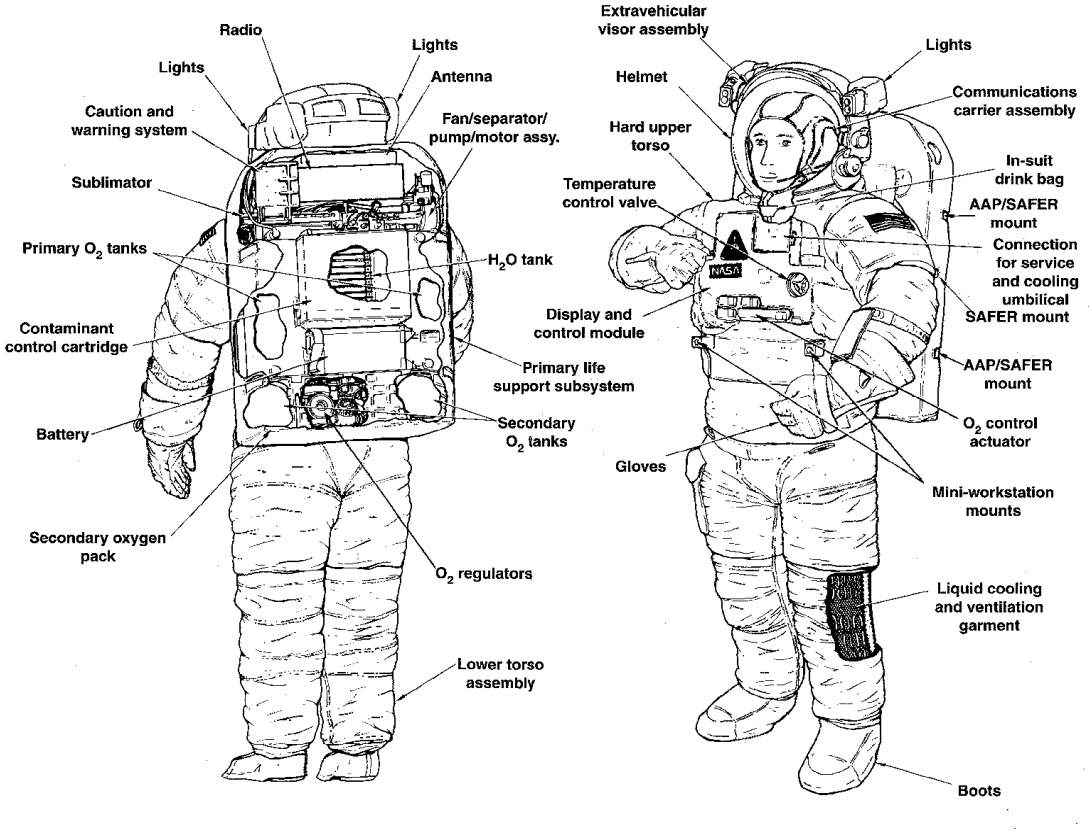
- **Background**
  - Contamination specification is 1 mg/ft2 for all non volatile residues (NVR's)
  - Hydrocarbon contamination ranged from 1.1 to 63.2 mg/ft2
  - Fluorocarbons are a constituent of braycote which is used as a lubricant during assembly
  - Silicone is a constituent of the O-ring
  - Hydrocarbons present an ignition threat in an O_2 environment

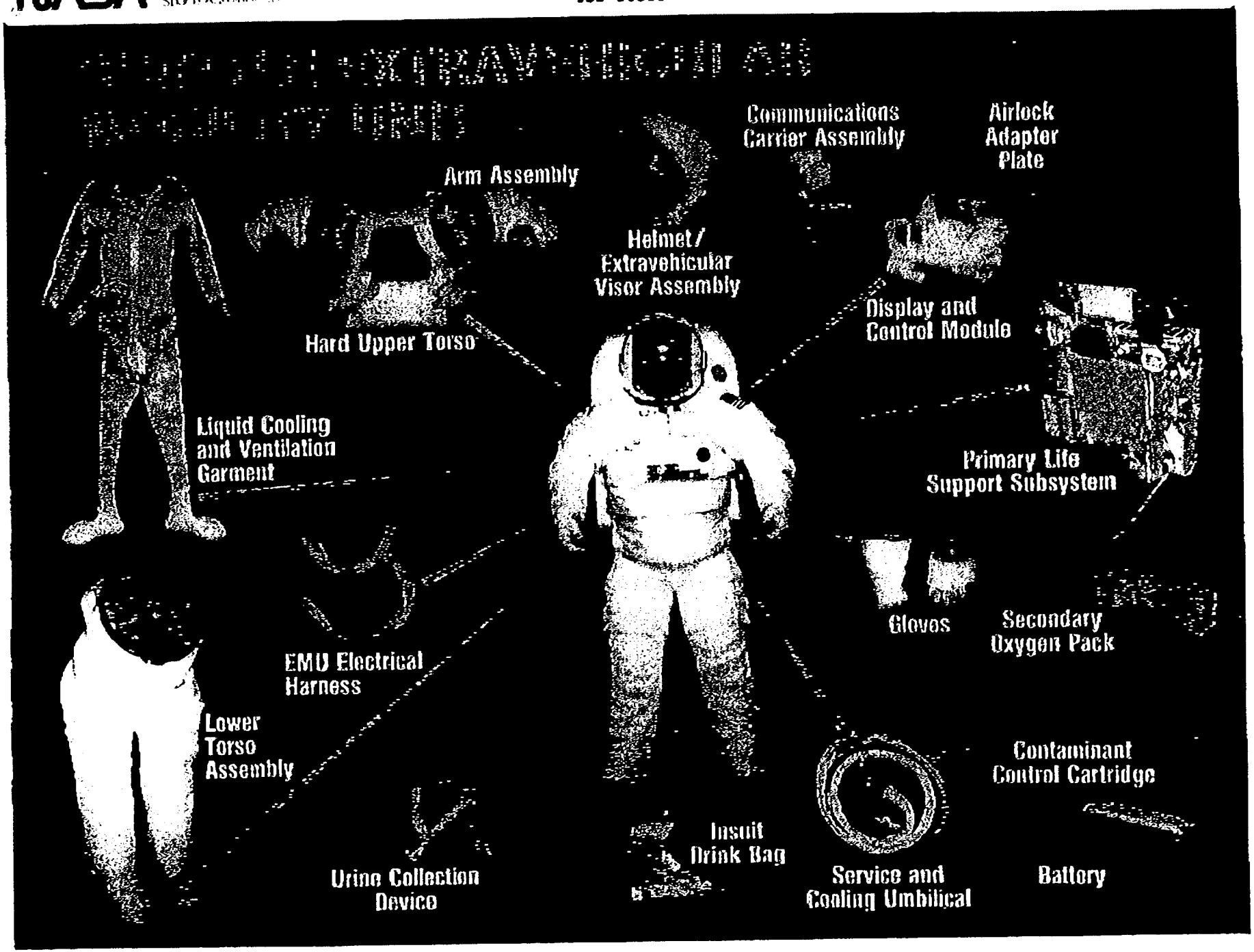
EMU Oxygen Contamination

- **Background (cont'd)**
  - EMU oxygen system is comprised of 2 subsystems which operate at different pressures
    - Primary System
      - Approximately 1000 ± 50 psi in primary tanks
      - 1.2 lbs of oxygen
      - Approximately 7 hour capability
      - Regulated from 1000 psi to 4.3 psi
    - Secondary System
      - Approximately 6000 ± 200 psi
      - 2.6 lbs oxygen
      - 30 minute emergency supply
      - Regulated from 6000 psi to 200 psi to 3.5 psi through a dual stage regulator

EMU Oxygen Contamination

FIGURE 1.1 EXTRAVEHICULAR MOBILITY UNIT REV E

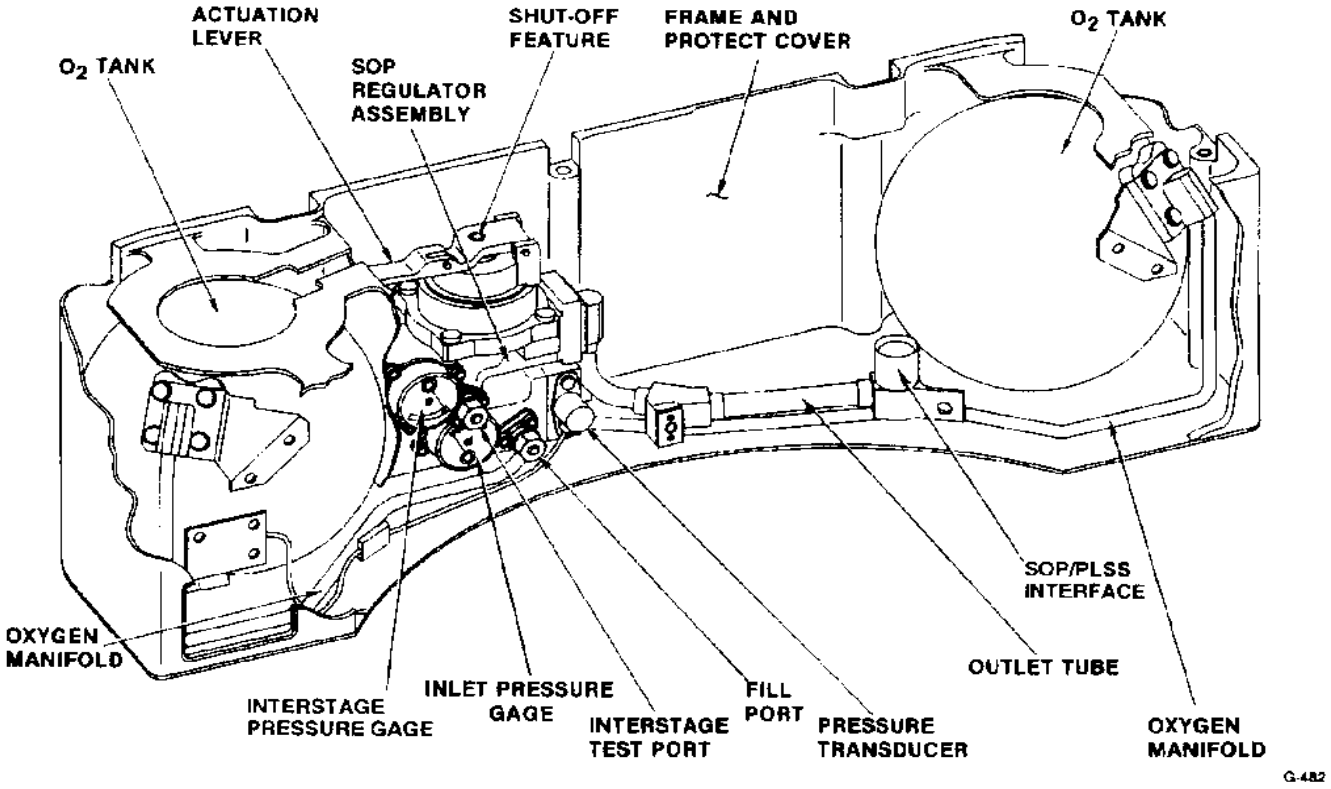




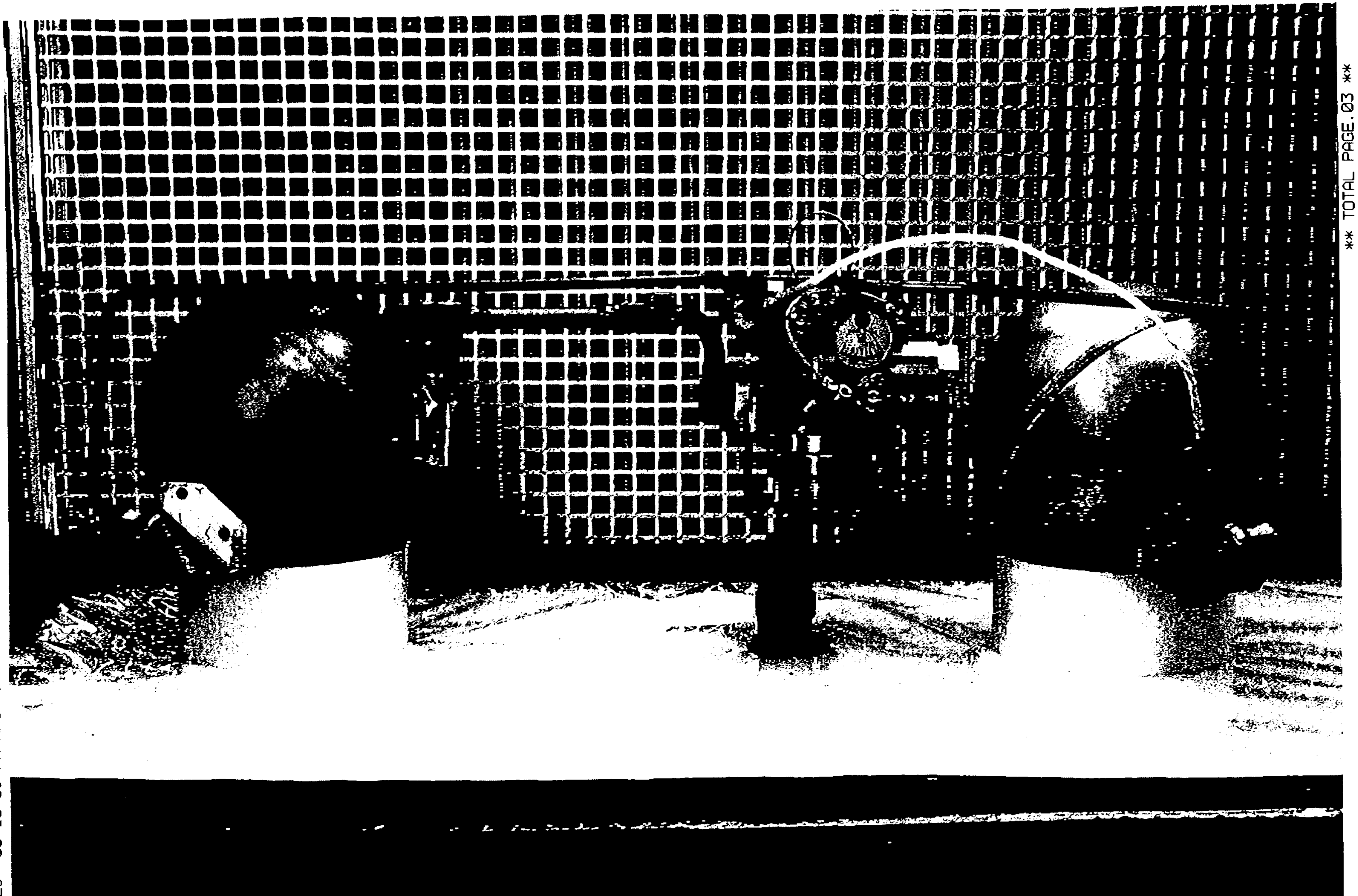
EMU Oxygen Contamination

ITEM 200 (CONT'D)

SECONDARY OXYGEN PACK (SOP)



JG8353186cv



ITEM 200
SECONDARY OXYGEN PACK
(EXTERNAL COVER REMOVED)

EMU Oxygen Contamination

- **Investigation Findings**
  - Secondary System
    - Upon discovering contaminants in SOP Regulator S/N 119, all SOP's were considered suspect and returned to the vendors for investigation
    - 12 SOP regulators were inspected and all were contaminated
    - 9 sets (2/set) of SOP bottles and 7 SOP manifolds were also inspected and found to be clean
  - Results support contamination by multiple oil types over time
    - Due to duration of a SOP retrofit/refurbishment program and charging frequency in the field no single lot of gas would have been used on all SOP's
    - Results of contamination indicate that no single component oil caused the observed contamination
      - Hydrocarbons found are compounds having 10 to 34 carbon bond chains
      - Hydrocarbon constituents are groups of multiple types of contaminants and vary from regulator to regulator
  - Primary System
    - Initially primary system was considered suspect
    - 3 primary system regulators, 2 sets (2 set) of primary bottles and manifolds/lines from 4 different primary systems were inspected and ALL found to be clean

EMU Oxygen Contamination

- **Investigation Findings (Cont'd)**
  - Investigation of Gas Sources
    - Hamilton Sundstrand Space Systems International (HSSSI)
    - United Space Alliance / Flight Crew Equipment (USA/FCE)
    - Carleton Technologies Incorporated (CTI)
    - JSC Facilities (Primary system only)
  - CTI and HSSSI sources are cryogenic generation plants
    - CTI subsequently monitors gas supplies (cryostat) and ensures no contamination greater than .002 mg is introduced
  - USA/FCE and JSC Facility sources are bottled gas supplies
    - All gases sampled and evaluated (within spec) for contamination prior to use
  - Investigation of GSE
    - All GSE at Carlton, Hamilton Sundstrand, JSC, and USA/FCE verified to be clean

EMU Oxygen Contamination

- **Root Cause**
  - No single identifiable root cause has been determined
  - Cumulative effect of contaminants condensing in regulator is most probable cause
    - Analysis confirms allowable hydrocarbon levels in O2 supply could condense in SOP regulator
    - Contamination isolated to SOP regulator

EMU Oxygen Contamination

- **Corrective Action and Flight Readiness Rationale**
  - Secondary Oxygen System
    - Filtration system was added at Hamilton Sundstrand and USA/FCE to ensure that contamination can not be introduced
      - Cold traps have been installed at USA and H/S SOP test stands
        - » Cold traps will scrub out contaminants present in gas supply for SOP processing
    - Carleton uses cryo source and cryo-stat for monitoring
    - All STS-106 SOP's (including regulators) have been disassembled, cleaned, reassembled, and acceptance tested
      - Subsequent flight SOP's will follow same process
  - Primary Oxygen System
    - Confident that primary systems are clean
    - Cold traps used to verify gas source cleanliness prior to PLSS processing

EMU Oxygen Contamination

- **Corrective Action and Flight Readiness Rationale**
  - PLSS regulator design does not provide an ignition source if contaminants are present
    - Oxygen compatible materials used throughout the design
    - White Sands testing of PLSS regulator design model and flight regulator with contamination present resulted in no ignition
      - Hydrocarbon oil was intentionally introduced at a contamination level of 100 mg/ft^2
      - Design model testing very conservative and was cycled four times the cycles for nominal qualification of a design for O_2 systems
      - Class I regulator was cycled 1.5 times the cycles for nominal qualification of a design for O_2 systems
      - The ignition mechanism of concern for a contaminated primary EMU regulator is adiabatic compression
        - » EMU design will not allow for rapid compression which is required for ignition

EMU Oxygen Contamination

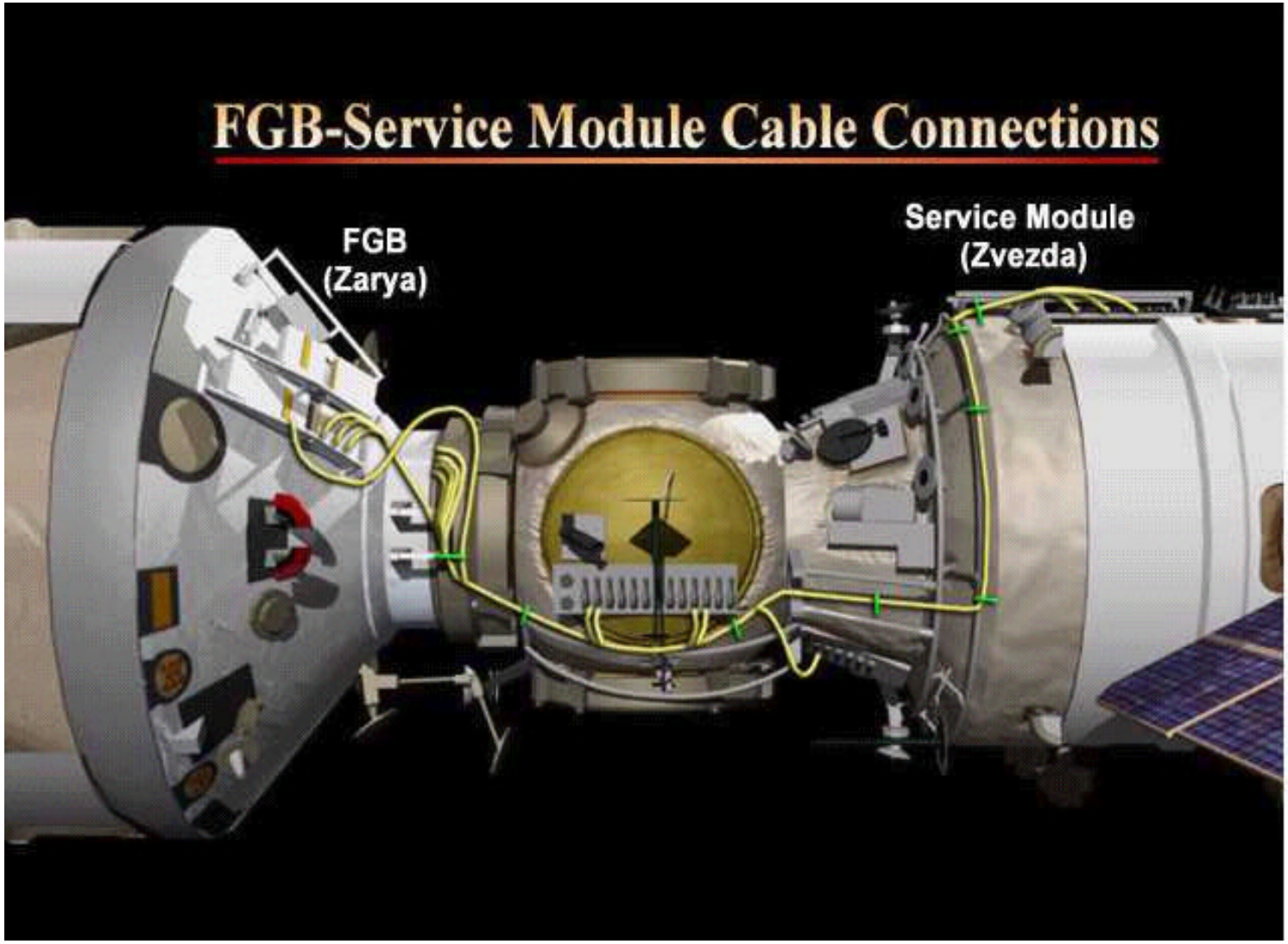
Summary

- **EMU oxygen systems, primary and secondary, are safe for operation to support the STS-106 mission.**

Back-up Charts

Scott Schoenherr
281-483-9892

SM-FGB Cable Installation



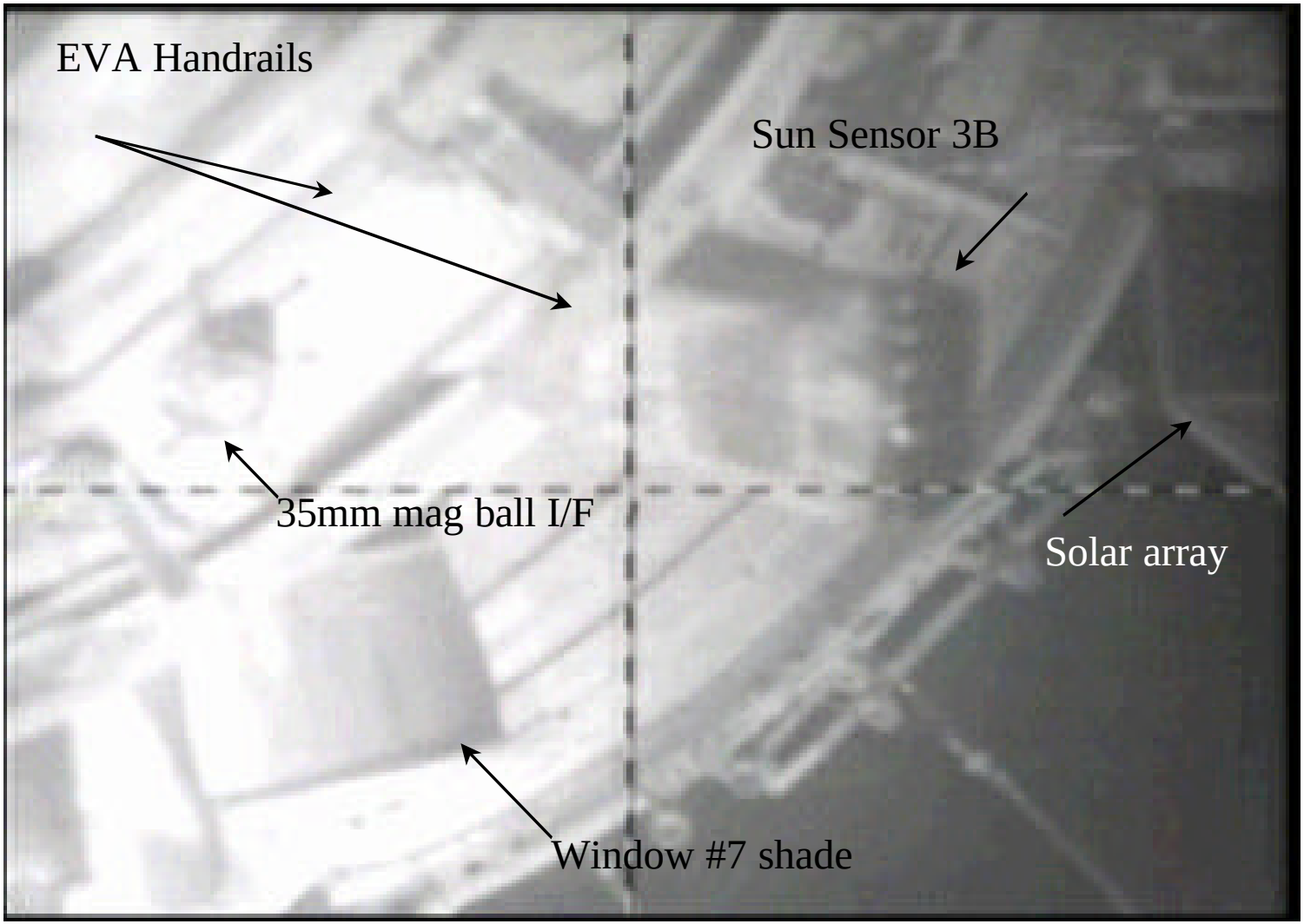
Scott Schoenherr
281-483-9892

SM -X Docking Target Task

- Confirmation from Russian telemetry and through verbal discussions that the launch lock pyro has fired
- Target verified in near stowed location by FGB docking camera
- Target data:
  - Deploy speed: 99° in 1.5 seconds (~ 1.7 ft/s)
  - Travel Path: 900 mm at tip of target
  - Deploy force: 3.5 kg (< 8 lbs)
- Crew will visually inspect the area and report to MCC-H
- Crew is cleared to touch target and manually push into position
- Procedure has gone through EVA community review for concurrence (EVA CCB)

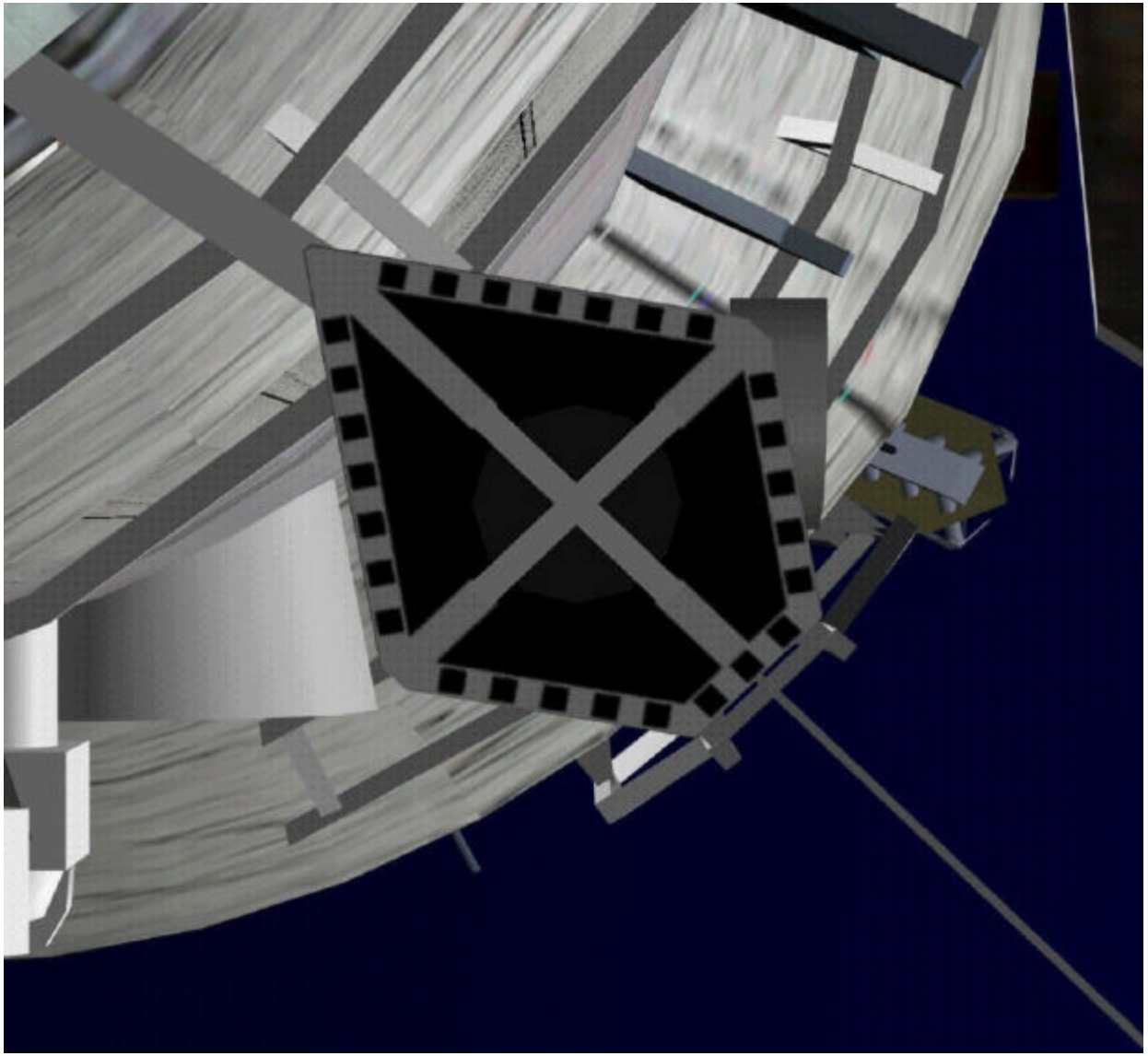
Scott Schoenherr
281-483-9892

SM -X Docking Target Photos



Scott Schoenherr
281-483-9892

SM -X Docking Target Photos



Scott Schoenherr
281-483-9892

SM -X Docking Target Photos

Scott Schoenherr
281-483-9892

SM -X Docking Target Photos

Scott Schoenherr
281-483-9892

Backup Charts

STS-106 Flight Readiness Review
EMU O_2 Contamination
Oxygen Compatibility

EMU O_2 Contamination Oxygen Compatibility

SOP Regulator NVR Levels

	Total NVR in mg											
	S/N 102	S/N 107	S/N 108	S/N 109	S/N 110	S/N 111	S/N 112	S/N 113	S/N 114	S/N 117	S/N 118	S/N 119
Bottle No. 1		0.10	0.10		0.50	0.10	0.10	0.10	0.20	0.20	0.10	
Bottle No. 2		0.10	0.10		0.60	0.10	0.20	0.10	0.20	0.40	0.40	0.30
Manifold		0.20	0.10				0.10	0.10	0.10	0.30	0.10	
Regulator Inlet	0.10	0.20	0.10	0.10	0.10	0.50	0.10	0.10	0.10	0.10	0.10	0.30
Fill Port	0.10	0.10	0.50	0.20	0.20		0.20	0.50	0.20	0.10	0.20	
Test Port	0.10	0.10	0.60	0.10	0.10		0.10	0.20	0.20	0.10	0.10	
1st Stage	1.30	0.60	0.60	0.30	1.30		0.60	0.70	0.70	0.30	0.70	1.80
2nd Stage	0.10	1.40	1.80	0.50	1.30	0.10	0.70	0.70	1.40	0.90	3.80	
Regulator Outlet	4.70	1.70	0.80	0.30	1.90	7.00	0.30	0.10	0.58	1.00	2.20	1.60

	Total Hydrocarbon NVR in mg											
	S/N 102	S/N 107	S/N 108	S/N 109	S/N 110	S/N 111	S/N 112	S/N 113	S/N 114	S/N 117	S/N 118	S/N 119
Bottle No. 1					0.02	0.04			0.16			
Bottle No. 2					0.02	0.08			0.20			
Manifold												
Regulator Inlet	0.01	0.02	0.03			0.04		0.04		0.02	0.04	0.03
Fill Port	0.07	0.03	0.13	0.04	0.03		0.05	0.07	0.17	0.05	0.05	
Test Port	0.02	0.01	0.19	0.07	0.08		0.07	0.03	0.16	0.03	0.07	
1st Stage	0.22	0.09	0.10	0.08	0.19		0.09	0.14	0.21	0.09	0.11	0.26
2nd Stage		0.10	0.07	0.40	0.11	0.01	0.09	0.13	0.09	0.10	0.10	
Regulator Outlet	0.47	0.04	0.36		0.10	1.90	0.30	0.05	0.05	0.06	0.06	0.05

EMU O_2 Contamination Oxygen Compatibility

SOP Regulator NVR Levels

	Total NVR in mg/ft2											
	S/N 102	S/N 107	S/N 108	S/N 109	S/N 110	S/N 111	S/N 112	S/N 113	S/N 114	S/N 117	S/N 118	S/N 119
Bottle No. 1		0.13	0.13		0.66	0.13	0.13	0.13	0.26	0.26	0.13	
Bottle No. 2		0.13	0.13		0.79	0.13	0.26	0.13	0.26	0.53	0.53	0.39
Manifold		1.56	0.78				0.78	0.78	0.78	2.35	0.78	
Regulator Inlet	18.18	36.36	18.18	18.18	18.18	90.91	18.18	18.18	18.18	18.18	18.18	54.55
Fill Port	14.29	14.29	71.43	28.57	28.57		28.57	71.43	28.57	14.29	28.57	
Test Port	13.89	13.89	83.33	13.89	13.89		13.89	27.78	27.78	13.89	13.89	
1st Stage	80.25	37.04	37.04	18.52	80.25		37.04	43.21	43.21	18.52	43.21	111.11
2nd Stage	10.31	144.33	185.57	51.55	134.02	10.31	72.16	72.16	144.33	92.78	391.75	
Regulator Outlet	156.67	56.67	26.67	10.00	63.33	233.33	10.00	3.33	19.33	33.33	73.33	38.28

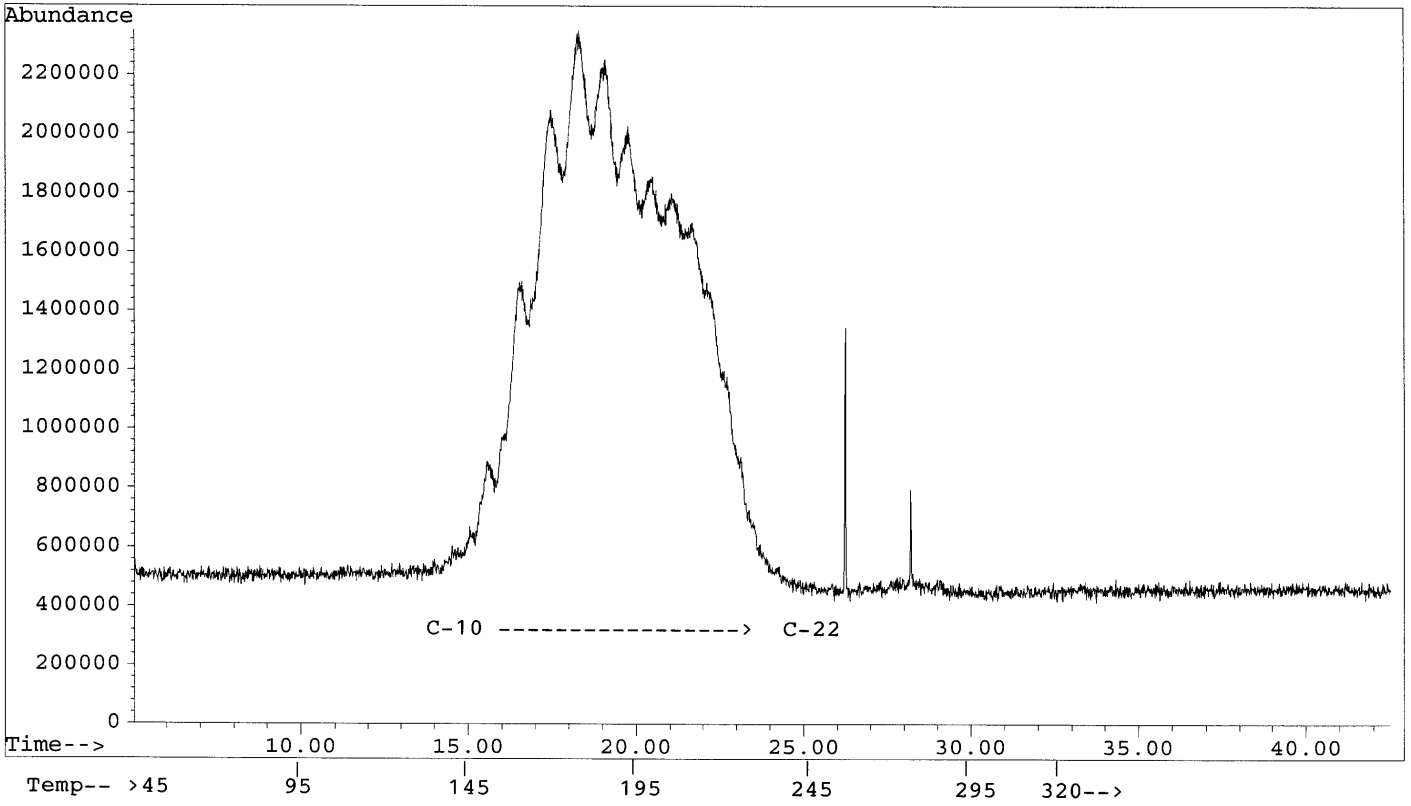
	Total Hydrocarbon NVR in mg/ft2											
	S/N 102	S/N 107	S/N 108	S/N 109	S/N 110	S/N 111	S/N 112	S/N 113	S/N 114	S/N 117	S/N 118	S/N 119
Bottle No. 1					0.03	0.05			0.22			
Bottle No. 2					0.03	0.10			0.26			
Manifold												
Regulator Inlet	1.82	4.00	5.82			7.27		6.91		3.64	7.09	5.89
Fill Port	9.29	4.86	17.86	5.43	4.29		7.29	10.43	24.29	6.71	7.29	
Test Port	3.06	1.39	26.39	9.03	10.83		9.58	4.17	21.53	4.72	9.58	
1st Stage	13.56	5.31	6.17	5.06	11.72		5.56	8.64	12.96	5.31	6.79	15.78
2nd Stage		10.62	7.22	41.24	11.26	1.03	8.88	13.78	8.80	9.79	9.79	
Regulator Outlet	15.67	1.43	12.00		3.33	63.23	10.00	1.57	1.52	1.87	2.00	1.08

EMU O_2 Contamination Oxygen Compatibility

- **Hydrocarbon Characterization**
  - Results indicate that no single component oil caused the observed contamination
  - Results indicate that no single multi-component oil caused the observed contamination
    - Hydrocarbon links found are from C10-C34
  - Results support contamination by multiple oil types (multiple sources and/or episodes)
  - Gas Chromatography/Mass Spectrometry utilized to analyze contamination

EMU O_2 Contamination Oxygen Compatibility

Chromatogram #3 - SOP Regulator S/N 102 Outlet Port



EMU O_2 Contamination Oxygen Compatibility

- **Active Ignition Mechanisms**
  - To have a fire need: fuel (oil), oxidizer (O2), and an ignition source with sufficient energy to ignite fuel
  - 12 Ignition mechanisms were considered consistent with NSS 1740.15 "NASA Safety Standard for Oxygen and Oxygen Systems"
  - Based on review, 4 were identified as being influenced by the presence of oil contamination
    - Compression Heating - The heat generated when a gas is compressed from a low pressure to a high pressure ignites the oil (diesel engine)
    - Particle Impact - A particle in a gas flow strikes a surface with enough energy to ignite the particle which then ignites the oil
    - Static Discharge - Flow induced charge build-up between two non-conducting surfaces which then discharge to ignite the oil
    - Flow Induced Friction - Turbulent gas flow does work on the polymers or oil causing the polymers or oil to ignite

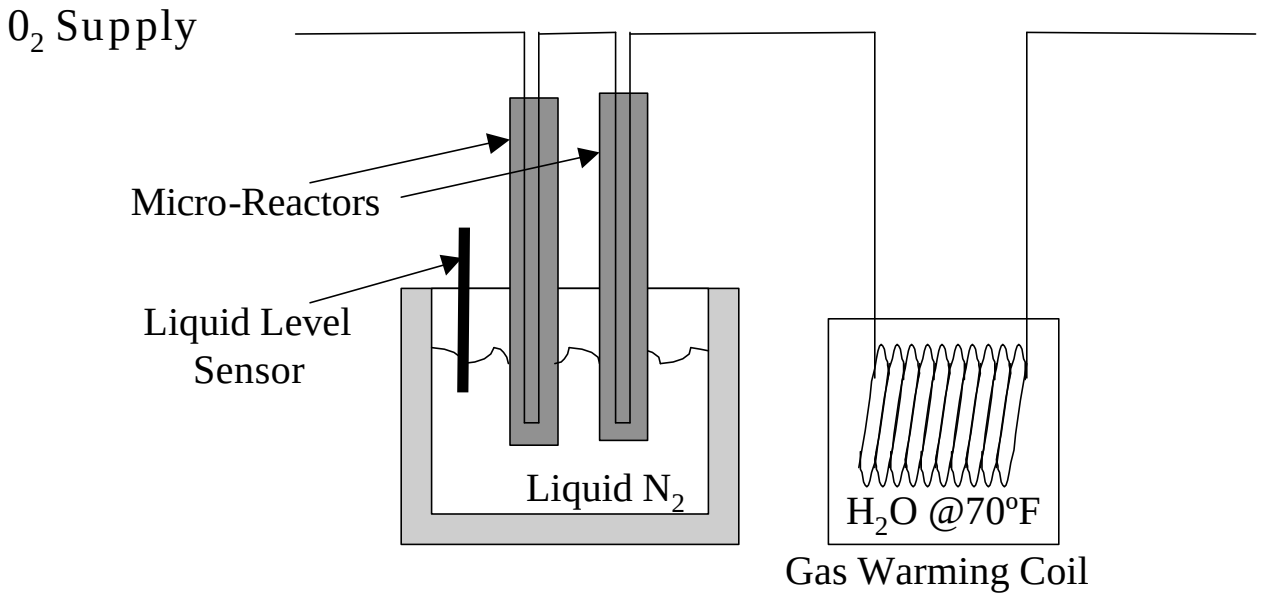
EMU O_2 Contamination Oxygen Compatibility

- **Ignition Potential and Controls - PLSS**
  - Compression Heating - Potential exists for compression from 10.2 psi to 950 psi
    - Test data indicate that design of the check valve and regulator including several orifices restrict pressurization to below that required for ignition
  - Particle Impact - Sonic velocities occur across regulator seats.
    - All downstream components are in a low pressure environment where all metals are nonflammable
    - Controlled by filters that limit particle size to a level where ignition of the particle is not possible
  - Static Discharge - All regions of the check valve and regulators are at a common potential and charge build-up is drained away
  - Flow Induced Friction - Leak across regulator seat could ignite oil on seat
    - Ignition mechanism is not observed in lower pressure systems
    - Controlled because flow removes flammable material from the ignition zone

EMU O_2 Contamination Oxygen Compatibility

- **A cold trap is a device that:**
  - Utilizes liquid nitrogen to condense contaminants
  - Physically separates the condensed contaminants from the gas due to increased viscosity
  - Assures a gas supply is clean

EMU O_2 Contamination Oxygen Compatibility



Production Cold Trap